BULLETIN

OF THE INSTITUTE OF METALS

VOLUME 4 SEPTEMBER 1958 PART 13

INSTITUTE NEWS

Election of Members

The following 26 Ordinary Members, 1 Junior Member, and 9 Student Members were elected on 5 August 1958:

As Ordinary Members

ALWAN, Abdul Sahib, B.Sc., Scientific Officer, British Iron and Steel Research Association, 140 Battersea Park Road, London, S.W.11.

BALLUFFI, *Professor* Robert Weirter, Sc.D., Associate Professor of Physical Metallurgy, University of Illinois, Urbana, Ill., U.S.A.

BATTEN, William Joseph Russell, Purchasing Agent, Emco Brass Manufacturing Co., Ltd., Westwood, Margate, Kent.

BENHAM, Peter Philip, M.Sc., G.I.Mech.E., G.R.Ae.S., Lecturer in Applied Mechanics, Imperial College of Science and Technology, London, S.W.7.

BRUNETAUD, Robert, Ing., Chef de Service Matières, Société Nationale d'Etudes et de Construction de Moteurs d'Aviation (S.N.E.C.M.A.), 92 Boulevard Kellermann, Paris (13e), France.

EDLUND, D. L., B.S., Ch.E., S.M., Sc.D., Metallurgist, 3235 Kennebec Road, Pittsburgh 34, Pa., U.S.A.

FISCHMEISTER, Hellmut F., Dr.Phil., Research Physicist, Metallografiska Institutet, Stockholm O, Sweden.

GADEAU, Robert André, Ing., Directeur Technique, Aluminium Français, 23 rue Balzac, Paris (8e), France.

GRUSSENMEYER, Joseph, Directeur-General, Société Métallurgique et Industrielle des Carbures et Métaux Durs (Durmetal), Route de Menandon, Pontoise (S. et O.), France.

HANCOCK, Edwin John, 45 Hangleton Drive, Golden Hillocks Road, Sparkhill, Birmingham 11.

HUSEINI, Syed Dastgir, B.E., Research Officer (Nuclear Metallurgy), Atomic Energy Commission, Victoria Road, Karachi, Pakistan.

LAMOND, John Alan, B.Sc., A.M.I.Mech.E., A.M.I.E.E., A.M.I.C.E., Joint Managing Director, W. H. A. Robertson and Co., Ltd., Bedford.

LARSON, Frank Robert, B.S., Ch.E., Physical Metallurgist, Watertown Arsenal Laboratories, Watertown 72, Mass., U.S.A.

MATHER, William Harvey, O.B.E., T.D., M.I.Mech.E., A.M.I.E.E., M.I.Prod.E., Director and General Manager, The Head-Wrightson Machine Co., Ltd., Commercial Street, Middlesbrough.

NELSON, Russell Charles, B.S.Met.E., D.Sc., Engineer-in-Charge, Metallurgical Laboratory, Chemical and Metallurgical Division, Sylvania Electric Products, Inc., Towanda, Pa., U.S.A.

NIELSEN, Erling Juul, Afdelingsleder, Struers Scientific Instruments, Skindergade 38, Copenhagen K, Denmark.

PERRITON, Ronald Clifford, M.B.A., A.I.M., Sales Engineer, Union Carbide Europa S.A., 40 rue du Rhône, Geneva, Switzerland.

PIRK, *Professor* Gustav W., Chief Metallurgist, Rome Cable Corp., Rome, N.Y., and Professor of Physical Metallurgy, Utica College of Syracuse University, Utica, N.Y., U.S.A.

PIRON, Robert, Ing., Directeur, Société Lorraine de Laminage Continu, 28 rue Dumont d'Urville, Paris (16e), France.

POOLE, Frederick Edward, B.Sc., Metallurgical Chemist, Osram Lamp Works, The General Electric Co., Ltd., Wembley, Middlesex.

SAKELLARIADIS, Athanasios, Chem.Ing., Chief Engineer, Copper and Aluminium Remelting Plants, Industrie Hellenique du Cuivre et de l'Aluminium S.A., rue de Pirée 252, New Faleron, Greece.

SMITH, Harold James, A.M.I.Mech.E., M.I.Prod.E., Managing Director, The Industrial Pyrometer Co., Ltd., 66–76 Gooch St., Birmingham 5.

SMITH, John Francis, B.A., Ph.D., Research Metallurgist, Iowa State College, Ames, Iowa, U.S.A.

SOLIMENE, Nicholas, Ph.D., M.A., Chemical Physicist, Technical Research Group, 17 Union Square West, New York 3, U.S.A.

WILLIAMS, William Critington, Jr., B.S., Chief Plant Metallurgist, Reynolds Metals Co., Alloys Plant, Sheffield, Ala., U.S.A.

WRIGHT, David Brian, B.Sc., Senior Scientific Officer, Atomic Weapons Research Establishment, Aldermaston, Berks.

As Junior Member

HITCHON, John William Francis, B.E., Research Student, School of Metallurgy, New South Wales University of Technology, Kensington, N.S.W., Australia.

As Student Members

CALOW, Clifford Aubrey, Undergraduate, Department of Metallurgy, University of Manchester.

CORDEROY, David John Haviland, Undergraduate, School of Metallurgy, New South Wales University of Technology, Kensington, N.S.W., Australia.

IRWIN, Ian Hector, Undergraduate, School of Metallurgy, New South Wales University of Technology, Kensington, N.S.W., Australia.

KANG, Il Koo, B.S., Department of Metallurgy, University of Manchester.

KIERNAN, Brian, L.I.B., Student, Department of Metallurgy, Battersea College of Technology, London, S.W.11.

LEES, Norman Blake, Undergraduate, Department of Metallurgy, University of Manchester.

WEHR, Allan G., B.S., Graduate Student, Metallurgy Department, School of Mines and Metallurgy, University of Missouri, Rolla, Mo., U.S.A.

WORTLEY, John Philip Atkinson, B.Sc., 24 Gravel Lane, Wilmslow, Cheshire.

WRENCH, Maxwell, Undergraduate, School of Metallurgy, New South Wales University of Technology, Kensington, N.S.W., Australia.

PERSONAL NOTES

M. J.-H. ALLEAUME has taken up an appointment as Engineer with Electricité de France, Clamart (Seine).

MAJOR C. J. P. BALL has been appointed a Director of the British American Metals Co.

SIR LAWRENCE BRAGG has been elected an Honorary Fellow of the Institute of Physics.

PROFESSOR DR. W. G. BURGERS, of the Technische Hogeschool, Delft, has been awarded the Luigi Losana Gold Medal of the Associazione Italiana di Metallurgia.

DR. R.W. CAHN has been made Reader in Physical Metallurgy at the University of Birmingham.

SIR JOHN COCKCROFT has been awarded the Niels Bohr Medal for 1958 in recognition of his special contributions towards the peaceful uses of atomic energy.

MR. W. CRAFTS, Associate Director of Research, Metals Research Laboratories, Electro Metallurgical Co., has been nominated Vice-President of the American Society for Metals for 1958–59.

MR. L. H. DAVENPORT has been appointed Supervisor, Materials Engineering Section, The Consolidated Mining and Smelting Company of Canada, Ltd., Trail, B.C.

DR. W. E. DENNIS has been appointed Assistant General Manager of the Redbourn Section of Richard Thomas and Baldwins, Ltd., Scunthorpe, Lincs.

DR. E. H. DIX, Jr., Assistant Director of Research, Aluminum Company of America, has been awarded the honorary degree of D.Sc. by the Carnegie Institute of Technology, Pittsburgh, Pa.

DR. A. B. EVEREST has been appointed European representative of the American Foundrymen's Society in place of the late Mr. V. Delport.

MR. J. T. FALLON, Chairman of the Incandescent Heat group of companies, was awarded the O.B.E. in the Birthday Honours' List.

DR. E. O. HALL, Lecturer in Physics at Sheffield University, has been appointed Associate Professor of Metallurgy at Newcastle University College, N.S.W., Australia.

MR. R. G. HARPER has been appointed Managing Director of Fry's Metal Foundries, Ltd.

DR. S. HARPER has been appointed Head of the General Metallurgy Section of the British Non-Ferrous Metals Research Association.

DR. R. HAYNES has left the Research Department of Imperial Chemical Industries, Ltd., Metals Division, to become Lecturer in Metallurgy at Loughborough College of Technology.

MR. E. M. HOLT has been appointed General Manager of Hoy Carbides, Ltd., Saunderton, High Wycombe, Bucks.

MR.W. H. L. HOOPER, of the Research Department, Imperial Chemical Industries, Ltd., Metals Division, has been seconded for a three-year period to Imperial Chemical Industries (New York), Ltd.

DR. S. T. JAZWINSKI, Director of Research of the Phoenix Iron and Steel Co., Harrisberg, Pa., has been awarded the D.Sc. degree of the Krakow Academy of Mining and Metallurgy.

MR. E. R. W. JONES has left The Mond Nickel Co., Ltd., and taken up an appointment with Imperial Chemical Industries, Ltd., Billingham Division.

DR. M. F. JORDAN has left Aluminium Laboratories, Ltd., to became Leader of the Fundamental Research Section of Murex Welding Processes, Ltd., Waltham Cross.

PROFESSOR S. KODA has been appointed a Professor in the Research Institute for Iron, Steel, and Other Metals, Tohoku University, Japan. He continues to hold his former post in the Faculty of Engineering, Hokkaido University.

MR. RAYMOND LEMMY has retired from the post of Assistant Editor of *Engineering* after 33 years on the editorial staff.

DR. E. S. MACHLIN, during sabbatical leave from Columbia University, is acting Director of Research for the Utica Metals Div., Kelsey-Hayes Co., Utica, N.Y.

MR. E. F. MAILLARD has been appointed Metallurgist to Tiltman Langley, Ltd., Redhill Aerodrome, South Nutfield, Surrey.

PROFESSOR I. OBINATA has been appointed Director of the Research Institute for Iron, Steel, and Other Metals at Tohoku University, Japan.

DR. G. OHIRA has been appointed Professor of Metallurgy at Tohoku University, Sendai, Japan.

MR. T. F. OLT, Director of Research of Armco Steel Corp.. Middleton, Ohio, has been elected Vice-President—Research,

MR. I. J. POLMEAR has been awarded the Florence Taylor Medal for 1957 for a paper entitled "Developments in Light Alloy Theory and Practice", which was submitted to the Melbourne Branch of the Australian Institute of Metals.

PROFESSOR GEORGE SACHS, of Syracuse University, has been awarded the honorary degree of Doktor-Ingenieur by the Bergakademie Clausthal in recognition of his distinguished services to general and applied metallurgy. The Technische Universität, Berlin, has elected Professor Sachs Ehrensenator.

Dr. R. E. Smallman has been appointed Lecturer in Physical Metallurgy at Birmingham University.

Dr. E. V. Tull has left N. C. Ashton, Ltd., and is now with the Ministry of Supply, M.E.X.E., Christchurch, Hants.

Dr. J. H. Watson, Chemist and Assayer at the Royal Mint, is President-Elect of the Institution of Mining and Metallurgy for 1958–59.

Dr. J. Weertman has been appointed a Scientific Liaison Officer at the U.S. Office of Naval Research in London.

Professor E. A. Wegelius, of Helsinki, has been elected President of the International Organization for Standardization.

Dr. B. C. Woodfine has been appointed Chief Metallurgist of the Atomic Energy Division of the General Electric Co., Ltd., Erith, Kent, in succession to Dr. W. E. Dennis.

Death

The Editor regrets to announce the death of:

Professor Carl Axel Frederick Benedicks, formerly Director of the Metallografiska Institutet, Stockholm, on 16 July. He joined the Institute in 1911 and was made an Honorary Member in 1937.

OBITUARY

Professor Dr. E. Houdremont

Edouard Houdremont, whose death occurred on 10 June, was born in Luxembourg in 1896. From 1916 to 1921 he studied metallurgy at the Technische Hochschule, Berlin, gaining the Dr.Ing. degree. In 1921 he entered the research department of the Krefeld steelworks, where he obtained extensive experience on alloy steels. Subsequently, in 1926, he joined Fried. Krupp of Essen, where he remained until his death. He was placed in charge of all research activities within the Krupp organization in 1943, and in the following year he was appointed to the Board and made Managing Director.

It was because he held this important position that after the war he had to undergo trial, with Alfred Krupp, at Nuremberg. He was sentenced to ten years' imprisonment, but was released after a few years on grounds of ill-health. He returned to Krupps and completed the construction of a modern well-equipped research department in 1957.

In addition to his industrial activities, Professor Houdremont lectured from 1934 onwards at the Technische Hochschule, Aachen. He was an acknowledged expert on all aspects of steels, especially alloy steels, and his knowledge and experience were incorporated in his well-known "Handbuch für Sonderstähle" first published in 1935 (third edition 1956). He was also the author or part-author of a great many research papers on various aspects of steel.

Professor Houdremont was the recipient of numerous honours. He was made an Ehrenbürger of the Technische Hochschule, Aachen, in 1952 and an honorary Dr.Ing. of the Technische Hochschule, Berlin, in 1954. In the same year he received the Carl Lueg Memorial Medal of the Verein Deutscher Eisenhüttenleute and in 1957 he was awarded the Peter Tunner Gold Medal of the Eisenhütte Oesterreich. He was an Honorary Member of the Société Française de Metallurgie and a Corresponding Member of the Académie des Sciences, Paris.

PERSONALITIES

Mr. C. F. J. Francis-Carter
(Chairman, South Wales Local Section)

Charles Francis Jack Francis-Carter was born in 1904 in London and educated at Queen Mary College. In 1924 he entered the Metallurgical Branch of the Research Department,

Woolwich Arsenal, where he worked first under the late Sir William Griffiths and subsequently, on the application of electrodeposition to armaments, under the late A. W. Hothersall.

In 1929, he joined Morris Motors, Ltd., Radiators Branch, where he was engaged on applications of technology to production processes and was responsible for bringing into operation one of the first large-scale automatic electroplating plants in the country.

Shortly after the outbreak of the last war he was appointed to take charge of a Government-sponsored project for the production of aluminium ingots from metal salvaged from crashed and obsolete aircraft. Mr. Francis-Carter was responsible for the planning and operation throughout the War of two plants (the "M.P.R.D.S.'s"), one in Oxford and a second, larger one, on Tees-side; between them these plants dealt with the combined arisings of metal from the R.A.F. and the U.S.A.A.F. in this country, together with a not inconsiderable quantity of German origin. For this contribution to the national effort, he was awarded the O.B.E. in 1944.

At the end of 1946, he joined the newly formed Aluminium Wire and Cable Co., Ltd., Port Tennant, Swansea, as General Manager, being appointed Managing Director in January 1955.

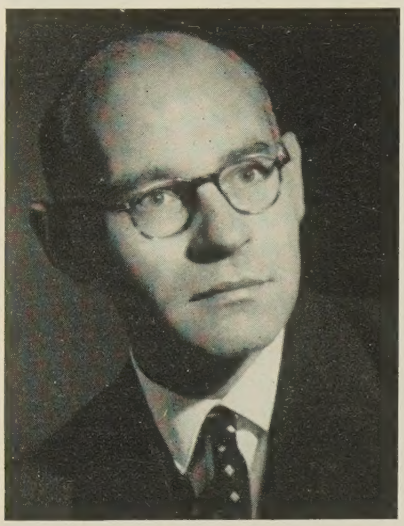
Mr. Francis-Carter has been a member of the Institute of

Metals since 1936 and has served on the Council since 1955. He has also served on the Council of the Electrodepositors' Technical Society and took part in the formation of the Midlands Centre of that Society in 1933. He is a Fellow of the Institution of Metallurgists, a Member of the Institution of Chemical Engineers, and a Fellow of the Royal Institute of Chemistry.

Mr. R. G. Harper
(Chairman, London Local Section)

Richard George Harper was born in 1915. He was educated at Dudley Grammar School and Birmingham University, graduating in Metallurgy in 1935.

He joined Fry's Metal Foundries, Ltd., in 1936 as the first member of their research department, and has remained with that company ever since. He was appointed to the Board as



Technical Director in 1954 and became Managing Director in 1958.

He became a member of the Institute in 1937, and is a Member of Council of the Printing and Packaging and Allied Trades Research Association.

Dr. C. E. Homer
(Chairman, Birmingham Local Section)

Charles Egbert Homer was born in 1911 and educated at Sebright School, Wolverley, and Birmingham University. Here he studied metallurgy, gaining the B.Sc. degree with first-class honours in 1931 and the Ph.D. degree in 1933. In that year he joined the Tin Research Institute, where he occupied several technical positions before leaving in 1942 to become Chief Metallurgist at the Castle Bromwich Works of Vickers-Armstrongs, Ltd. (Aircraft Section).

After a short period as Chief Metallurgist to Darwins, Ltd., Sheffield, Dr. Homer joined Tube Investments, Ltd., in 1946. Until 1957 he was Superintendent of Metallurgical Research at the firm's Department of Development and Research at Birmingham. Last year, on the integration of this department into the Tube Investments Technological Centre at Walsall, he was placed in charge of the Materials Division at the Centre.

Dr. Homer was President of the Birmingham Metallurgical Society in 1955–56. He is a Fellow of the Institution of Metallurgists and served on its Council from 1946 to 1951. He is a member of the American Society for Metals and the

Iron and Steel Institute, as well as of the Institute of Metals, which he joined in 1934.

LETTERS TO THE EDITOR

A Simplified Law of Strain-Hardening

The mechanism of strain-hardening in ductile metals and the thermodynamical theories concerning the influence of temperature on the subsequent kinetics of recovery and recrystallization of such cold-worked metals, have been the subject of much controversy and, not least, of some excellent researches designed to elucidate these phenomena.

Much of the earlier controversy arose, principally, between the two schools of thought: one considered recovery and recrystallization as two distinct but correlated mechanisms, on the one hand, while the other regarded it as the continuous exhibition of a single mechanism, with varying intensities over the time-scale of observation. The excellent researches of Cook and Richards [1] on the rate and mechanism of recrystallization in copper could be interpreted on the assumption that the rate of recrystallization depended on the current degree of recovery; this evidence seemed to disprove, quite conclusively, that recrystallization could be described as a single-stage, activated process with a simple exponential time law governing the rate of recrystallization.

It would appear that the mechanism of strain-hardening presents a dilemma similar to that relating to recrystallization, since here again the increase of yield stress with the degree of plastic pre-strain does not obey a simple exponential law. Voce,[2] in a recently published letter, considers strain-hardening to be governed by two correlated mechanisms (" two regimes of strain-hardening ") and the somewhat complex law of strain-hardening that he derives bears a strong resemblance to the interpretation of recrystallization kinetics by Cook and

Richards. It is the purpose of the present letter to consider a simpler law of strain-hardening which, it could be claimed, fits in quite well with most models of strain-hardening based on the interaction of the stress fields of dislocations.

Considering the simple exponential strain-hardening law:

$$\frac{Y - Y_0}{Y_\infty - Y_0} = 1 - \exp(-\lambda\varepsilon) \quad (\lambda = 1/\eta_c \text{ as in Voce's theory}^2)$$

where Y = current yield stress, Y_0 = threshold yield stress, Y_∞ = asymptotic yield stress, ε = logarithmic pre-strain, and λ = reciprocal characteristic strain, it is obvious that such a law is characterized by a single constant λ, which, in effect, means, throughout any macroscopic volume of the metal, a uniform distribution of dislocation loops with constant stress amplitudes of the associated periodic stress fields. The constancy of the λ parameter therefore leads to a model of the strain-hardening mechanism which conflicts with the behaviour of real metals. It is, however, much more realistic to consider the distribution of dislocation loops to be characterized by a spectrum of λ values and, using the simplified assumption that there exists a continuous spectrum:

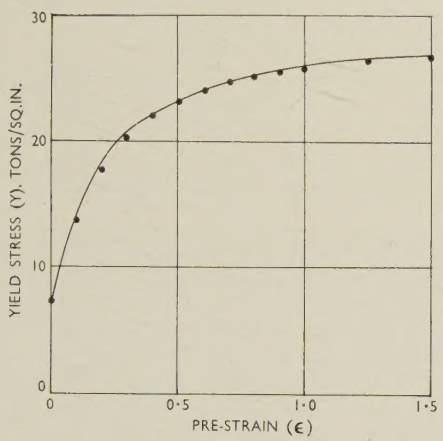


FIG. 1.—Application of simplified law of strain-hardening to copper.

— Experimental curve (*Ford* [3])
• Values calculated from:

$$\frac{Y - Y_0}{Y_\infty - Y_0} = 1 - \left[\frac{1 - \exp(-\lambda_m\epsilon)}{\lambda_m\epsilon}\right]$$

where Y = current yield stress; Y_0 = threshold yield stress (7·3 tons/in.^{2}); Y_∞ = asymptotic yield stress (28·6 tons/in.^{2}); λ_m = reciprocal characteristic logarithmic strain (7·7).

$$0 \leqslant \lambda \leqslant \lambda_m \quad (\lambda_m = \text{maximum value of } \lambda)$$

Then, the yield-stress law, for any macroscopic volume of material, may be written:

$$\frac{Y - Y_0}{Y_\infty - Y_0} = \frac{1}{\lambda_m}\int_0^{\lambda_m} [1 - \exp(-\lambda\varepsilon)]\,d\lambda$$

or,
$$\frac{Y - Y_0}{Y_\infty - Y_0} = 1 - \left[\frac{1 - \exp(-\lambda_m\varepsilon)}{\lambda_m\varepsilon}\right]$$

Some preliminary calculations, albeit approximate, give the following values for copper: Y_0 = 7·3 tons/in.^{2}; Y_∞ = 28·6 tons/in.^{2}; λ_m = 7·7 (η_c = 0·13), and the resulting points (Fig. 1) are in quite good agreement with the experimental curve given by Ford.[3]

W. J. HARRIS

De Havilland Aircraft Co., Ltd.,
Edgware, Middlesex.

REFERENCES

1. M. Cook and T. Ll. Richards, *J. Inst. Metals*, 1947, **73**, 1.
2. E. Voce, *Bull. Inst. Metals*, 1958, **4**, (8), 50.
3. H. Ford, *Proc. Inst. Mech. Eng.*, 1948, **159**, 115.

The Strain-Hardening Function

It is gratifying to know that my attempt to devise a comprehensive strain-hardening equation has stimulated the interest of Mr. W. J. Harris. His proposal is certainly less complicated than mine, yet both suffer from deficiencies which seem to be inescapable when one tries to embrace the whole curve in a single equation. In particular, neither can be solved algebraically for strain, and consequently both lack an important attribute of any respectable strain-hardening function, namely that it should cope satisfactorily with the combination of logarithmic strains by direct addition. Lacking this property, it is difficult to deal successfully with partially cold-worked materials. In sharp contrast, the simple exponential function shows the yield stress attained in a preliminary operation to be explicitly the threshold stress at which subsequent deformation begins, when the strains are considered additively, and so demonstrates in a direct and intelligible way the essential continuity of the strain-hardening process.

Though I have analysed many hundreds of experimental strain-hardening curves, I have never yet found one which could not be accurately fitted by two consecutive regimes of the simple exponential equation, with tangential junction between them. Generally, the first regime extends up to or beyond the critical point corresponding to the maximum load in tension, and so covers most of the practical requirements for common cold-forming processes. Moreover, experience shows that the constants for this main regime reflect the properties of the material, whereas those for the subsequent regime are influenced to a much greater degree by the experimental conditions. It follows that by separating the two regimes, more reliance can be placed on the constants for the important part of the curve when the rate of strain-hardening is high, than would be the case if the whole were embraced in a single equation.

For such reasons, I would reiterate and emphasize my view that comprehensive equations are of academic interest rather than of practical value, and that for all ordinary purposes it is preferable to use the simple exponential function. I would add that division of the curve into consecutive regimes is consistent with the work of Cook and Richards [1] on the mechanism of cold deformation.

E. VOCE

Copper Development Association,
London, W.1.

REFERENCE

1. M. Cook and T. Ll. Richards, *J. Inst. Metals*, 1941, **66**, 1; 1943, **69**, 351; 1950–51, **78**, 463.

Kinetics of Recovery of Cold-Worked Metals from Internal-Friction and Elasticity Measurements

Since the early work of Förster and Köster [1] in 1937, it has been recognized that recovery processes in heavily cold-

worked materials tend to increase the elastic modulus and decrease the logarithmic decrement, so that these two properties are displaced in the direction of their normal unstrained values. In a recent letter Kamel and Attia [2] confirmed that heavily swaged high-purity cadmium exhibits these effects. Annealing experiments carried out at temperatures up to 140° C. indicated that the rate of change of these two variables varied with temperature according to an Arrhenius equation. The activation energy calculated from the changes of internal friction, approximately 21·6 k.cal./mole, was similar to that associated with the rate of increase of elastic modulus. From this evidence it was concluded that the two processes were uniquely related.

The authors comment that " . . . the slope of the lines in Fig. 2 (p. 57) indicate that the activation energy shows a slight but noticeable increase as the recovery takes place at higher temperatures ". Of greater significance, however, is the fact that the calculated activation energies appear to increase with the degree of recovery. When data for the complete recovery range are plotted, as in the present Fig. 1, the divergencies of slope become more pronounced than is suggested by the original Fig. 2, which presents data only for the lower degrees of recovery. Activation energies calculated from the times taken to achieve high rates of recovery are rather greater than the mean value of 21·6 quoted by Kamel and Attia.

Because of the difficulty of taking accurate measurements from Fig. 1 (p. 57) in the original letter, too much importance

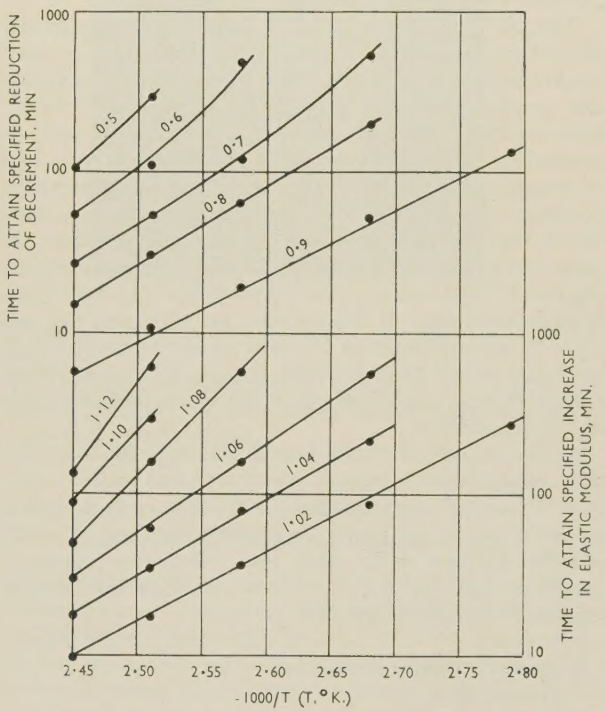


FIG. 1.—Recovery of cold-worked cadmium over the complete recovery range, based on measurements of internal friction and modulus of elasticity.

should not be ascribed to the exact values of activation energies plotted in the present Fig. 2. These curves do emphasize, however, that even within the context of the work described it may be premature to ascribe a unique, converse relationship to those aspects of the recovery process in cadmium which result in a change of decrement and elastic modulus with time after straining.

The recovery processes in high-purity copper, for example, are somewhat anomalous and in the earlier plastic stages the internal friction can actually increase with time after straining.[3]

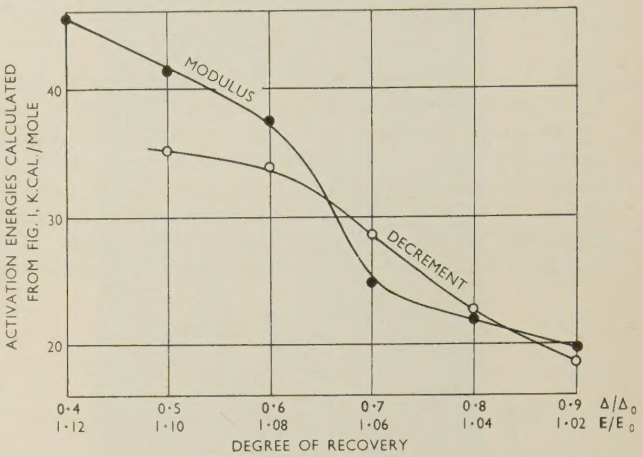


FIG. 2.—Activation energies for recovery of cold-worked cadmium, based on Fig. 1 of Kamel and Attia.[2]

Whereas the changes of internal friction that occur with time after the application of small increments of strain depend upon the impurity concentration, the associated recovery of elastic modulus does not appear to be purity-sensitive. This latter conclusion has also been arrived at by A. D. N. Smith.[4]

It is probable therefore that important differences exist between the recovery processes in heavily worked and lightly strained metals. Internal-friction and elastic-modulus measurements afford an elegant and convenient method for following these processes. Perhaps Dr Kamel and Dr. Attia have studied the vibrational behaviour of lightly deformed cadmium and could indicate to what extent the degree of purity affects the changes, with time after straining, of internal friction and elastic modulus.

A. S. DARLING

Johnson, Matthey and Co., Ltd.,
Wembley, Middlesex.

REFERENCES

1. F. Förster and W. Köster, *Z. Metallkunde*, 1937, **29**, 116.
2. R. Kamel and E. A. Attia, *Bull. Inst. Metals*, 1958, **4**, (9), 56.
3. A. S. Darling, *J. Inst. Metals*, 1956–57, **85**, 489.
4. A. D. N. Smith, *Phil. Mag.*, 1953, [vii], **44**, 453.

Effect of Delay in Quenching on the Microstructure of a Titanium–2·4 At.-% Nickel Alloy

McQuillan [1] has reported on the disagreement found in the position of the $\beta/(\alpha+\beta)$ boundaries of some titanium-rich systems and concludes that the most probable cause of error is delay in quenching, in particular the delay which occurs on quenching specimens enclosed in sealed silica tubes. He shows a series of microstructures of a titanium–2·4 at.-% nickel alloy quenched after delay times between " instantaneous " and 10 sec. The differences in microstructures are remarkable, and it would appear that serious errors in positioning the $\beta/(\alpha+\beta)$ phase boundary might arise if quenching were delayed even

for fractions of a second. Since the use of evacuated and sealed silica tubes is a convenient and simple method of protecting reactive metals and alloys during heat-treatment, it was considered desirable to ascertain whether the delay in quenching specimens, which occurs on breaking the tubes under water, could give rise to misleading results when determining phase boundaries. Some experiments have therefore been carried out on the effect on the microstructure of this method of quenching compared with rapid quenching.

The alloy chosen was a titanium–2·4 at.-% nickel alloy, made from titanium sponge, which after arc-melting had a hardness of 120 D.P.H., and high-grade nickel. A 50-g. button of the alloy was prepared in a conventional type of arc furnace, and specimens from the button were homogenized by heating at 1100° C. for 4 hr. in a vacuum, followed by water-quenching.

Two specimens similar in size (about $\frac{3}{16}$ in. cube) were placed close together in a modified Rosenhain quenching furnace,[2] one being enclosed in a small silica tube similar to those used for heat-treatment except that one end of the tube was left open. Each specimen was wrapped with a few turns of fine molybdenum wire to prevent direct contact with the silica. The small silica tube was secured to one end of a molybdenum wire, the other end of which was attached to a steel rod working through a Wilson seal.

In each experiment the specimens were heated at 900° C. in a vacuum for $\frac{1}{2}$ hr. before furnace-cooling to the required quenching temperature, at which they were held for various times. The small silica tube was then withdrawn into a cold part of the furnace tube by operating the rod passing through the Wilson seal, the other specimen remaining meanwhile in the hot part of the furnace. After a lapse of 5 sec., which is about twice as long as is necessary to withdraw a silica tube and break it under water, the water supply was turned on and the apparatus filled with water, the specimens being washed from the furnace into a large flask.

After the preliminary treatment at 900° C., one pair of specimens was cooled to 840° C., a temperature which was found to lie just within the β phase field, and two pairs were cooled to 835° C. (α + β phase field); one of the latter pairs was held at that temperature for 15 min., the other pair held for $2\frac{1}{2}$ hr., before quenching.

Photomicrographs of four of the six specimens are shown in Figs. 1 and 2. The specimen quenched rapidly from the β range shows a fine martensitic structure (α′) (Fig. 1 (*a*)), while the corresponding specimen quenched after 5 sec. delay shows a fine lamellar structure of transformed β but no massive α (Fig. 1 (*b*)). After rapid quenching from the (α + β) phase field (835° C.), after both $\frac{1}{4}$ and $2\frac{1}{2}$ hours' heating, the microstructure consisted of equilibrium α in a fine martensitic matrix (Fig. 2 (*a*)). Delay in quenching again resulted in a fine lamellar matrix, many of the lamellæ having nucleated on the massive α plates (Fig. 2 (*b*)). In contrast to the results given by McQuillan, it is concluded that although short delays

FIG. 1 (*a*)

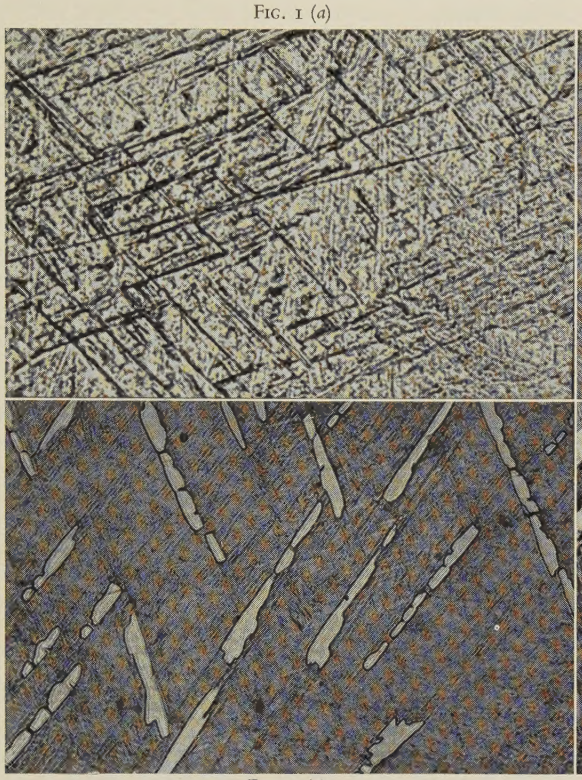


FIG. 1 (*b*)

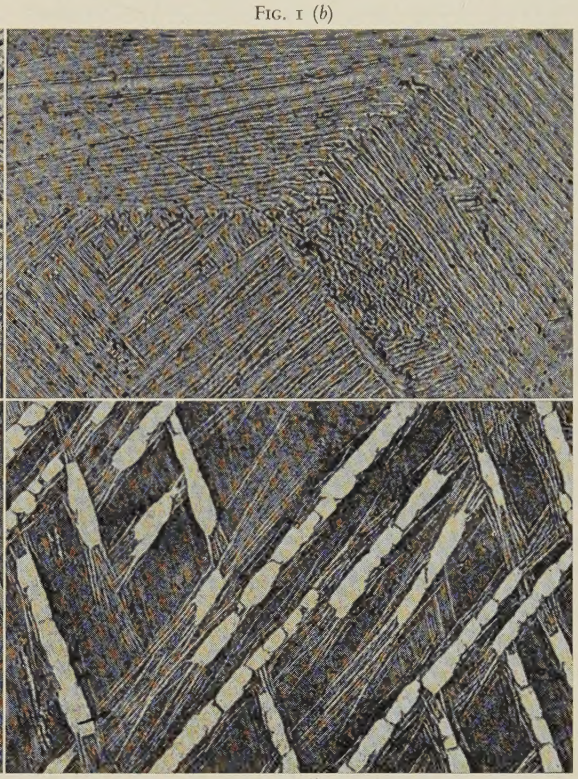


FIG. 2 (*a*)

FIG. 2 (*b*)

PHOTOMICROGRAPHS OF TITANIUM—2·4 AT.-% NICKEL ALLOY

FIGS. 1 (*a*) and (*b*).—Heated $\frac{1}{2}$ hr. at 900° C., furnace-cooled to 840° C., held for 2 min., then: (*a*) immediately water-quenched; (*b*) water-quenched after 5 seconds' delay. × 500.

FIGS. 2 (*a*) and (*b*).—Heated $\frac{1}{2}$ hr. at 900° C., furnace-cooled to 835° C., held $\frac{1}{4}$ hr., then: (*a*) immediately water-quenched; (*b*) water-quenched after 5 seconds' delay. × 150.

in quenching result in some coarsening of the transformed β, the differences in microstructure between rapidly quenched specimens and specimens quenched from silica tubes are not likely to result in errors in placing the $\beta/(\alpha+\beta)$ boundary.

Similar results have been obtained by means of micro-Jominy tests on this alloy. In these experiments small cylindrical specimens $\frac{5}{8}$ in. long × $\frac{1}{8}$ in. dia. were quenched from one end after heating to just above or below the $\beta/(\alpha+\beta)$ phase boundary. The quenched ends of the specimens showed, respectively, a fine martensite structure or plates of massive α in a fine martensitic matrix; whilst the less rapidly cooled ends showed lamellar transformed β or massive α plates in a matrix of lamellar transformed β which had nucleated on the α plates, as in the first series of experiments.

From these experiments the $\beta/(\alpha+\beta)$ boundary for the titanium–2·4 at.-% nickel alloy would seem to lie just below 840° C., which is the mean of the temperatures recorded by McQuillan [3] and by Margolin, Ence, and Nielsen [4] (805° and 873° C.). It is of interest to note that the American workers obtained substantially the same result with alloys prepared from either iodide or sponge titanium.

The reasons for these large differences in the position of the $\beta/(\alpha+\beta)$ boundary are not apparent, but they illustrate another of the anomalies frequently encountered in the investigation of titanium alloy systems.

Acknowledgement.—The work described above has been carried out as part of the General Research Programme of the National Physical Laboratory and this letter is published by permission of the Director of the Laboratory.

T. H. Schofield
A. E. Bacon

Metallurgy Division,
National Physical Laboratory,
Teddington, Middlesex.

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The Growth of Single Crystals in Aluminium Alloys by the Strain-Anneal Method

Single crystals produced by techniques of growth from the melt suffer from the disadvantage that they usually possess lineage structures and uneven surfaces. In the case of alloys, there is the added complication that segregation effects may occur. Recrystallization methods are superior in these respects, and it is desirable therefore that single crystals of alloys should be grown by such a technique if possible.

It is apparent from the work of Williamson and Smallman [1] that an important requisite for the growth of single crystals by the strain-anneal technique is a steep temperature gradient in the specimen, in order to minimize the chance of nucleation in front of the growing interface. As alloying elements are introduced into pure metals in increasing amounts, it becomes more and more difficult to grow single crystals, unless the temperature gradient also is increased. Thus, it was found that with a gradient furnace made with a resistance winding over a silica tube and incorporating water-cooling to increase the gradient, single crystals could not be grown in aluminium–copper alloys containing more than about 3% copper. Increasing the temperature gradient in the specimen by lowering it into a molten salt bath enabled 5% copper crystals to be grown without any difficulty.

This was achieved by arranging for the specimen to be lowered vertically into the salt bath, over which was placed a steel sheet very near the surface of the salt and through which the rod was passed. Four air jets, arranged radially, impinged on the specimen about $\frac{1}{2}$ in. above the level of the salt and removed heat likely to be conducted along the rod, so that a steep temperature gradient could be maintained. The specimens were in the form of $\frac{1}{8}$-in.-square rod and were about 10 in. long.

A series of experiments was conducted with this apparatus, and the main conclusions were as follows:

(1) The best results were obtained by growing the crystals into a fine-grained and completely recrystallized matrix. This condition was obtained by flash-annealing the cold-drawn rods at a high temperature.

(2) The amount of strain given to the specimen before growth was not highly critical, a variation of 0·3% in 1·25% being permissible. (The optimum strain may be slightly higher than this for certain alloys.)

(3) In general, the temperature of the salt bath had to approach the solidus temperature of the alloy being treated, e.g. with aluminium–copper alloys the minimum temperature for successful growth was about 30° C. below the solidus.

(4) The rate of descent of the specimen must not exceed a critical value, although the speed may be reduced below this value without detriment to growth. The effect of increased alloying was to decrease the speed that could be tolerated; thus, with pure aluminium speeds of 1·0 cm./hr. could be used, but with most alloys the speeds employed had to be about 0·5 cm./hr.

An indication of the length of crystals that could be grown in various alloys is given below:

	in.		in.
Al–5·0% Cu	10	Al–4·2% Ge	10
Al–7·0% Zn	10	Al–4·5% Mg	2
Al–1·3% Si	10	Al–8·6% Ag	$\frac{1}{2}$

Ten-inch crystals were grown in more dilute alloys.

This work constituted part of an investigation carried out for the Industrial Group of the United Kingdom Atomic Energy Authority.

N. Gane

Department of Metallurgy,
King's College,
Newcastle-upon-Tyne.

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The Thorium–Cerium System

It was of particular interest to me to read the paper by Weiner, Freeth, and Raynor on "Lattice Spacings and Melting Points in the Thorium–Cerium System" in the December 1957 issue of the *Journal* [1] because of a manuscript on the same subject that I submitted in February 1957 to the *Journal*. My manuscript was rejected in favour of the other paper on the grounds that the latter contained more information. In the meantime my manuscript has been published in the August 1957 issue of *Philips Research Reports*,[2] so I am glad to have the

opportunity to make some comments on the paper by Weiner *et al.* in the light of my own experience and results.

First of all it is a pleasure to learn that their general conclusions are in complete accord with mine. However, I am not in agreement with certain details. In the first place, in connection with the shape of the lattice-parameter curve given in Fig. 2, I feel that the experimental data and the authors' conclusions from it are open to some criticism. Secondly, I should like to make a comment on the phase diagram in Fig. 3.

As regards the lattice-parameter data, Weiner *et al.* have given more measured points than I have, and moreover they give their results to four decimal places. I am inclined to believe that the minimum they find, where up to 30 at.-% cerium I found only a constant lattice parameter, is right. But I doubt whether the precision of their data is justified by the conditions of preparation, especially in respect of the initial steep fall of the lattice parameter. Weiner *et al.*, in their discussion, suggest the possibility that this effect is due to a scavenging action of cerium, but afterwards reject this explanation on the grounds that the effect persists up to 30 at.-% cerium. Thus they neglect the possibility that two effects are superposed, namely the scavenging action and, afterwards, the effect of the dissolution of cerium atoms in the thorium lattice as such. There is a statement in the paper that convinces me that the X-ray specimens were not degassed thoroughly enough. The significant phrase occurs on p. 188, second paragraph: "... were more probably due to CeH_2".

Let us suppose for a moment that some hydrogen was present, dissolved in the pure thorium. This hydrogen affects the lattice parameters in a marked way, as is well known. An addition of cerium would cause most of the hydrogen to precipitate as CeH_2, leaving a thorium lattice with only as much hydrogen in it as could co-exist in equilibrium with CeH_2, and therefore contracted to more normal proportions. This assumption is supported by the value of the lattice parameter of thorium found by James and Straumanis,[3] a parameter nearly identical with the value found by Weiner *et al.* at the end of the steep fall in their diagram. With the help of the data of James and Straumanis and of Weiner *et al.*, we can make an estimate of the amount of hydrogen present in Weiner's thorium. Upon hydriding thorium, there appears almost immediately a second phase, thorium hydride (ThH_2), which is body-centred tetragonal with a deformed CaF_2 structure. This phase is in equilibrium with thorium having a certain amount of hydrogen dissolved in it. How great this amount is we can only guess, as no precise measurements have been made so far. The relation between the two phases is very simple. The same is true for the rare earths and their hydrides (see Mulford and Holley[4]). At higher temperatures their regions of existence merge, so it is reasonable to assume that the lattice parameter increases continuously with hydrogen content. We can now take Straumanis' value 5·074 kX for pure thorium and the values for body-centred tetragonal ThH_2 given by Rundle, Shull, and Wollan[5] ($a_0 = 4{\cdot}10$ and $c_0 = 5{\cdot}03$ Å.) and find the composition of the "pure" thorium of Weiner *et al.* having $a = 5{\cdot}082$ kX. By interpolating linearly in terms of the cell volumes, which is not unreasonable, even if the originally cubic lattice is deformed (cf. Yakel[6]), we find the composition $ThH_{0{\cdot}032}$. In order to bind this dissolved hydrogen, an addition of 1·6 at.-% cerium would be needed.

In Table I of the paper under discussion we observe at this point the beginning of a more normal slope of the lattice-parameter curve, which we may now attribute to the effect of the cerium addition alone. The latter effect, as I stated in my paper, must find its explanation in the anomalous compressibility of the cerium atoms, and I was glad to read that the opinion of Weiner, Freeth, and Raynor, though expressed in different words, is essentially the same. The fact that, if we disregard the steep part, the initial slope of the curve is about equal to that of the straight line running between the values for pure thorium and for the compressed cerium phase of Bridgman supports these conclusions.

As regards the equilibrium diagram in Fig. 3, it may be remarked that the cerium-rich δ phase might well have the b.c.c. structure similarly to the thorium-rich β phase. This would be in agreement with the fact that many f.c.c. metals transform to a b.c.c. lattice at high temperatures. If this is indeed the case, there is a fair chance that an uninterrupted series of b.c.c. solutions exists everywhere below the solidus. The latter would then show no discontinuities. However, the accuracy of the solidus-temperature determinations (cf. Table I) is inadequate to decide between this possibility and a solidus curve with two discontinuities as given in Fig. 3.

J. H. N. VAN VUCHT

Philips Research Laboratories,
Eindhoven,
Netherlands.

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BRITISH NUCLEAR ENERGY CONFERENCE

New Member Society of the B.N.E.C.

At a meeting of the B.N.E.C. Board on 16 July, 1958, it was decided to admit to membership The Joint Panel on Nuclear Marine Propulsion.

This organization was set up jointly in 1956 by the following four societies: The Institute of Marine Engineers, The Institution of Naval Architects, The Institution of Engineers and Shipbuilders in Scotland, and The North-East Coast Institution of Engineers and Shipbuilders.

The admission of this new body brings the total number of constituent societies comprising the B.N.E.C. to nine.

B.N.E.C. Lecture Symposium on the Geneva Conference

To help scientists and engineers to assimilate the large amount of material (over 2000 papers) produced for the second International Conference on the Peaceful Uses of Atomic Energy (Geneva, 1–13 Sept. 1958), the B.N.E.C. have planned a one-day Lecture Symposium to take place in March, 1959. The time and place will be announced later.

For the purposes of the Symposium, the Geneva Conference

papers will be classified into six or seven groups, and leading experts in each field will attempt to highlight the most important aspects of the new information.

The lectures will be printed in the April 1959 issue of the *Journal* of the B.N.E.C.

Symposium on " Nuclear Fuel Cycles "

The Institute of Physics, one of the constituent bodies of the B.N.E.C., is arranging a Symposium on " Nuclear Fuel Cycles " to be held in London on 22 and 23 January 1959.

The programme is as follows:

Session 1 (*a*) " Long-term reactivity changes "
(*b*) " Theory of once-through fuel cycles "
(*c*) " Perturbations due to fuel cycles ".
Session 2 " Optimization of fuel cycles for nuclear power stations ".
Session 3 " Fuel cycle operational problems ".

The papers invited will cater mainly for persons working in the field, and will deal with the applied-physics aspects of the fuel cycles which form the basis of the immediate nuclear power programme. Abstracts (but not preprints) of the papers to be read or presented at the Symposium will be available early in January.

Application forms for tickets to attend the Symposium are obtainable from the Secretary of The Institute of Physics, 47 Belgrave Square, London, S.W.1, and should be returned as soon as possible.

The Symposium will be published only in the *Journal* of the British Nuclear Energy Conference.

OTHER NEWS

The Association of Light Alloy Refiners and Smelters

Alar Ltd. and the Federation of Light Metal Smelters have formed a combined organization named the Association of Light Alloy Refiners and Smelters. A free technical advisory service will continue to operate from 3 Albemarle Street, London, W.1. (MAYfair 2901.)

The British Investment Casters' Technical Association

A new technical association serving the investment-foundry industry using expendable-pattern techniques for the production of industrial metal castings has been formed under the title of The British Investment Casters' Technical Association.

The objects and scope of the new organization are entirely devoted to technical aspects of investment casting and will include such activities as the preparation of specifications for materials and testing procedures, the improvement of production techniques, expansion of the application of investment castings, and the general exchange of technical information within the industry.

At the inaugural meeting held in London on 11 June, 1958, attended by the representatives of twenty-five companies, the following were elected as Members of Council: Mr. D. H. Armitage, P. I. Castings (Altrincham) Ltd. (*Chairman*); Mr. R. W. N. Danielsen, Deritend Precision Castings Ltd. (*Vice-Chairman*); Mr. W. Foyers, H. &. F. Precise Castings Ltd.; Mr. G. A. Tomkinson, D. Napier & Son Ltd.; Mr. N. Walker, Hadfields Ltd.

Through the courtesy of the B.S.C.R.A., the address of the newly formed Association will be 5 East Bank Road, Sheffield 2. Mr. J. Bolton has been appointed Secretary.

Alloy Strengthening at Elevated Temperatures

The High-Temperature Materials Committee of the Institute of Metals Division of the Metallurgical Society of A.I.M.E. plans to sponsor a symposium at the February 1959 meeting of the A.I.M.E. on the topic " Alloy Strengthening at Elevated Temperatures ". Authors are invited to submit papers covering original work of an experimental or theoretical nature which contributes to a better understanding of the role of alloying elements in the strength of materials at elevated temperatures. Research work on the scientific aspects of problems concerned with the functions of impurities, solute elements, and dispersed particles in determining the resistance of materials to flow and fracture at elevated temperatures will be acceptable.

The papers will be accepted for presentation on the basis of an extended abstract or synopsis of at least 250 words covering the scope and conclusions of the work. The abstracts should be submitted in three copies to the IMD Programs Committee, The Metallurgical Society of A.I.M.E., 29 West 39th Street, New York 18, New York, by 1 November, 1958, plus one copy to Dr. R. W. Guard.

Conference on Interfacial Phenomena

The Physical Society's winter conference on the physics of the solid state will be held in the Cavendish Laboratory, Cambridge on 18, 19, and 20 December, 1958, starting at 2.30 p.m. on Thursday, 18 December, and ending at 1 p.m. on Saturday, 20 December. Accommodation will be available in King's College by kind permission of the College Council; the charge will be 35*s*. per day including breakfast, lunch and dinner.

The subject of the conference will be interfacial phenomena, and it is hoped that papers will be given on some or all of the following subjects: (1) Structure of vacuum-evaporated layers on single-crystal substrates; (2) structure of electrodeposited layers; (3) epitaxy; orientation of crystals on various substrates; (4) grain-boundary phenomena; the interface between different phases in metals; and (5) the interface between solid and liquid phases.

Investigators who would like to contribute papers are invited to write to Professor N. F. Mott, Cavendish Laboratory, Cambridge.

Post-Graduate Short Courses

The Department of Metallurgy, College of Technology, Gosta Green, Birmingham 4, proposes to offer two post-graduate courses during the Autumn Term, beginning in October 1958.

(1) The Metallurgy of Nuclear Power Materials.
(2) Spectrographic and Chemico-Physical Analytical Techniques for Metallic Materials.

The course on Nuclear Power Materials is intended for technical staff engaged in research and development on nuclear

reactors, and for students proceeding to advanced metallurgy examinations. Ten lectures will be given on successive Tuesday evenings, beginning on 7 October, 1958.

Extraction, fabrication, and physical properties of the fissile metals and of those non-fissile metals of special interest in reactor technology will be dealt with, together with the effects of radiation. The development of fuel elements and canning materials will be reviewed, as will the metallurgy of reactor structural work.

The course on Spectrographic and Chemico-Physical Analytical Techniques for Metallic Materials is intended for metallurgists and chemists engaged in research and development work. Subjects to be dealt with include spectroscopy and its application to both ferrous and non-ferrous alloys, polarography, absorptiometry, and the established electrochemical methods. The course will consist of twelve lectures held on successive Wednesday evenings, beginning on 8 October, 1958.

The lectures will be illustrated by optical aids, together with laboratory equipment. The meetings will comprise a lecture, with demonstrations and discussions. Full details of each programme, and application forms, can be obtained from the Department. The fee for each course will be £2. 2*s*. 0*d*.

" The Technology of Light Alloys "

A course of six lectures on " The Technology of Light Alloys " will be given at the Kingston Technical College, Fassett Road, Kingston-on-Thames, on successive Tuesday evenings at 7.0 p.m., beginning on 11 November.

The subjects of the lectures are: " Design, Structure, and Properties of Magnesium Alloys," by K. G. Bailey; (2) " Corrosion and Protection of Magnesium Alloys," by W. F. Higgins; (3) " Production Control and Inspection of Aluminium Alloys," by F. Kasz; (4) " Structures, Properties, and Heat-Treatment of Aluminium Alloys," by E. Elliott; (5) " Corrosion and Protection of Aluminium Alloys," by F. C. Porter; and (6) " Fatigue of Light Alloys," by P. L. Teed.

" Refractories "

A course of ten lectures on " Refractories, Their Manufacture, Properties, and Applications " is to be delivered by Mr. L. R. Barrett at the Borough Polytechnic on Fridays at 7.0 p.m., beginning on 10 October. The course is intended to provide a detailed and up-to-date survey of refractories and the refractories industry. The registration fee is £1. Registration forms may be obtained from the Secretary, Borough Polytechnic, Borough Road, London, S.E.1.

" Recent Developments in Metal Finishing "

A course of eight lectures under the title " Recent Developments in Metal Finishing " will be delivered at the Borough Polytechnic on Wednesdays at 7.0 p.m., beginning on 8 October. The course is intended to provide a detailed and up-to-date survey of some selected methods of metal finishing. It will also include lectures on human relations in the plating industry and on costing. The fee for the course is £1. Further details are available from the Principal, Borough Polytechnic, Borough Road, S.E.1.

" New Metals and High-Temperature Materials "

A special course on " New Metals and High-Temperature Materials " will be given at the Bradford Institute of Technology at 7.0 p.m. on Wednesdays from 15 October to 10 December 1958. The fee for the course is £2 5*s*. A list of the lectures and a registration form can be obtained from the Registrar, Institute of Technology, Bradford 7.

DIARY

Local Sections and Associated Societies

2 October. Birmingham Local Section. " Some Effects of Nuclear Radiation on Materials ", by Professor A. H. Cottrell. (College of Technology, Gosta Green, Birmingham 4, at 7.0 p.m.)

2 October. London Local Section. Chairman's Address: " Metals and Modern Printing Processes ", by R. G. Harper. (17 Belgrave Square, London, S.W.1, at 6.30 p.m.)

7 October. East Midlands Metallurgical Society. Presidential Address by A. S. Angus. (Electricity Service Centre, Smithy Row, Nottingham, at 7.30 p.m.)

7 October. Oxford Local Section. " Stress Corrosion ", by Dr. T. P. Hoar. (Cadena Café, Cornmarket Street, Oxford, at 7.0 p.m.)

8 October. Manchester Metallurgical Society. Presidential Address by J. Y. Davies. (Manchester Room, Central Library, Manchester, at 6.30 p.m.)

9 October. Leeds Metallurgical Society. " Tool Steels ", by K. Hill. (Lecture Room C, Chemistry Wing, The University, Leeds 2, at 7.15 p.m.)

9 October. Liverpool Metallurgical Society. Presidential Address: " Alternative Methods of Iron and Steel Production ", by Dr. C. Bodsworth. (Library of the Department of Metallurgy, The University, 146 Brownlow Hill, Liverpool 3, at 7.0 p.m.)

14 October. South Wales Local Section. " Beryllium ", by Dr. G. C. Ellis. (Metallurgy Department, University College, Swansea, at 6.30 p.m.)

16 October. Birmingham Local Section. " The Historical Development of the Rolling Mill ", by E. C. Larke. (College of Technology, Gosta Green, Birmingham 4, at 6.30 p.m.)

16 October. Southampton Metallurgical Society. Presidential Address: " Metallurgy in the Foundry ", by Dr. O. P. Einerl. (Southampton University, at 7.15 p.m.)

20 October. North East Metallurgical Society. " High-Strength Weldable Steels ", by Dr. K. J. Irvine. (Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, at 7.15 p.m.)

22 October. Manchester Metallurgical Society. " Martensitic Transformations ", by Dr. J. W. Christian. (Manchester Room, Central Library, Manchester, at 6.30 p.m.)

APPOINTMENTS VACANT

THE MOND NICKEL CO., LTD.

METALLURGICAL RESEARCH

Applications are invited from Physical Metallurgists for a post as Senior Investigator on the research staff of the Birmingham Laboratory of The Mond Nickel Co., Ltd.

The work involves primarily long-term research investigations on the properties of nickel-base materials, with particular reference to the influence of gaseous environments. An understanding of the behaviour of existing materials is sought, with the aim of developing improved alloys. Publication of results will be encouraged. Preference will be given to University-trained graduates with post-graduate research experience.

Salary will be in accordance with experience and qualifications. Pension and assurance schemes are in operation and in appropriate cases, assistance can be given for housing. Applications, which will be treated in confidence, should give details of age, qualifications and experience and be addressed to The Manager, Development and Research Department, The Mond Nickel Co., Ltd., Thames House, Millbank, London, S.W. 1. Please mark envelope " Confidential L.59 ".

A.E.R.E. HARWELL

Scientific Officer Class

There are vacancies for Honours Graduates to carry out research, much of it basic and affording opportunities for publication, into problems associated with the Nuclear Power Programme.

POST 1167(*A*) A PHYSICIST to study phase changes induced by irradiation in nuclear reactors using a specially designed X-ray diffractometer. Postgraduate experience of X-ray crystallography is required.

POST 1167 (*B*) METALLURGISTS, PHYSICISTS, and CHEMISTS with a flair for novel techniques to investigate physical properties and development of PLUTONIUM fuels for very advanced reactors.

Salary between £645 and £1425.

For application form and details send a POST CARD to the Group Recruitment Officer (1167/233), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Experimental Officer Class

There are vacancies in the following fields for experimentalists with the experience indicated:

(*a*) Corrosion studies of Be, U, and Zr in gases (Chemical kinetics and handling of pure gases).
(*b*) Properties and development of Pu fuels for advanced reactors (metallurgical or physical techniques).
(*c*) Electron microscopy to study irradiation damage, dislocation theory and plastic deformation (Electron microscopy and photography).
(*d*) Non-destructive testing using existing techniques and developing new ones (Relevant).
(*e*) X-Ray diffractometry; X-Ray fluorescent spectrometry; electron diffraction (Wide experience not essential).

Salary: £480–£1215, depending on age and experience of applicants, who should have H.N.C., Inter Degree, or equivalent qualifications.

Send POST CARD for details and application form to Group Recruitment Officer (1182/233), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

METALLURGICAL ENGINEER required by organization in Leicestershire. Successful applicant will be required to advise on metallurgical problems and preferably finishing processes, including plating, polishing, and painting, &c. Duties will include occasional visits to engineering firms throughout the country. Membership of professional institution and ability to work on own initiative essential. Good salary and superannuation under F.S.S.U. Send full details including age, qualifications, experience, and present salary in confidence to Box No. 443, The Institute of Metals, 17 Belgrave Square, London, S.W.1.

METALLURGIST or CHEMIST
rising to
TECHNICAL DIRECTOR

Young Company operating unique metal-treatment process, now in course of world-wide expansion, requires highly qualified Metallurgist or Chemist, age 30 to 40. Starting salary at least £2000 p.a. or more commensurately with suitability of applicant for position and experience. Bonus, pension.

Company's process now being applied in many diverse industries, including aero, nuclear, rocketry.

A unique opportunity for man of top technical ability, initiative and inventive flair. Kindly write fully to Box No. 444, The Institute of Metals, 17 Belgrave Square, London, S.W.1. Applications will be treated in strict confidence.

PRODUCTION MANAGER required by expanding Light Alloy Foundry in Birmingham Area. Candidates to have sound knowledge of gravity-die and sand-casting production methods and must have had previous experience in a similar capacity. Responsible pensionable post with reliable company. Reply, in confidence, giving full details of experience, age, and salary range, &c., to Box No. 445, Institute of Metals, 17 Belgrave Square, London, S.W.1.

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